South Atlantic Climate Observing System Workshop

Presented by
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NOAA/AOML

Climate Observation Program Workshop Focus on the Ocean
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CLIVAR/OOPC/IAI WORKSHOP ON THE SOUTH ATLANTIC CLIMATE OBSERVING SYSTEM

February 6 – 8, 2003
Angra dos Reis – Brazil

Edmo Campos (INPE, Brazil)
Alberto Piola (SHN, Argentina)
Co-chairs

Sponsors: *CLIVAR, OOPC, IAI*
Funding: *IAI, ONRIFO, WCRP, US-CLIVAR, IOC, INPE/CPTEC, IOUSP*

The SACOS Workshop was motivated by the belief that the South Atlantic circulation influences, directly or indirectly, the variability of the regional and global climate.

Workshop Goals

- To provide an overview of the scientific understanding of the influence of the South Atlantic Ocean on the regional and global climate.

- To discuss existing and identify new elements for a South Atlantic observing system required for a more complete understanding of the climate system in regional and global scales.

Workshop Goals (cont.)

• To integrate the region's diagnostic, modeling and observational communities and to develop joint actions and principles for a long-term observing strategy.

•To identify potential funding sources and associated operational partners.

PRESENTATIONS

1. *Review of South Atlantic intraseasonal to interdecadal variability.*
(**C.Vera**, W. Hazeleger, I. Wainer, J. Servain)

2. *The South Atlantic role on the global thermohaline circulation* (**A.Piola,** A. Gordon, E. Campos)

3. *Interocean Exchanges*
(W. de Ruijter, S. Cunningham, A. Gordon, **J. Lutjeharms**, R. Matano and A. R. Piola)

4. *South Atlantic links and impacts to regional and global climate* (**A. Grimm**, A. Robertson, Chris Reason)

5. *The South Atlantic Observing System*
(**S. L. Garzoli**, M. Johnson, A. Piola, C. Provost)

6. *The Mesoscale Circulation of the South Atlantic Ocean: Does it Matters to Climate?*
(**R. Matano**, B. Barnier, E. Campos, A. Coward, J. McLean, E. Palma, T.Penduff, M.Schouten, A-M. Treguier, I. Wainer and D. Webb)

7. *The role of the South Atlantic in the variability of the ITCZ*
(Y. Kushnir**,** **A. Lazar**, M. Barreiro, P. Rizzoli)

Working Groups

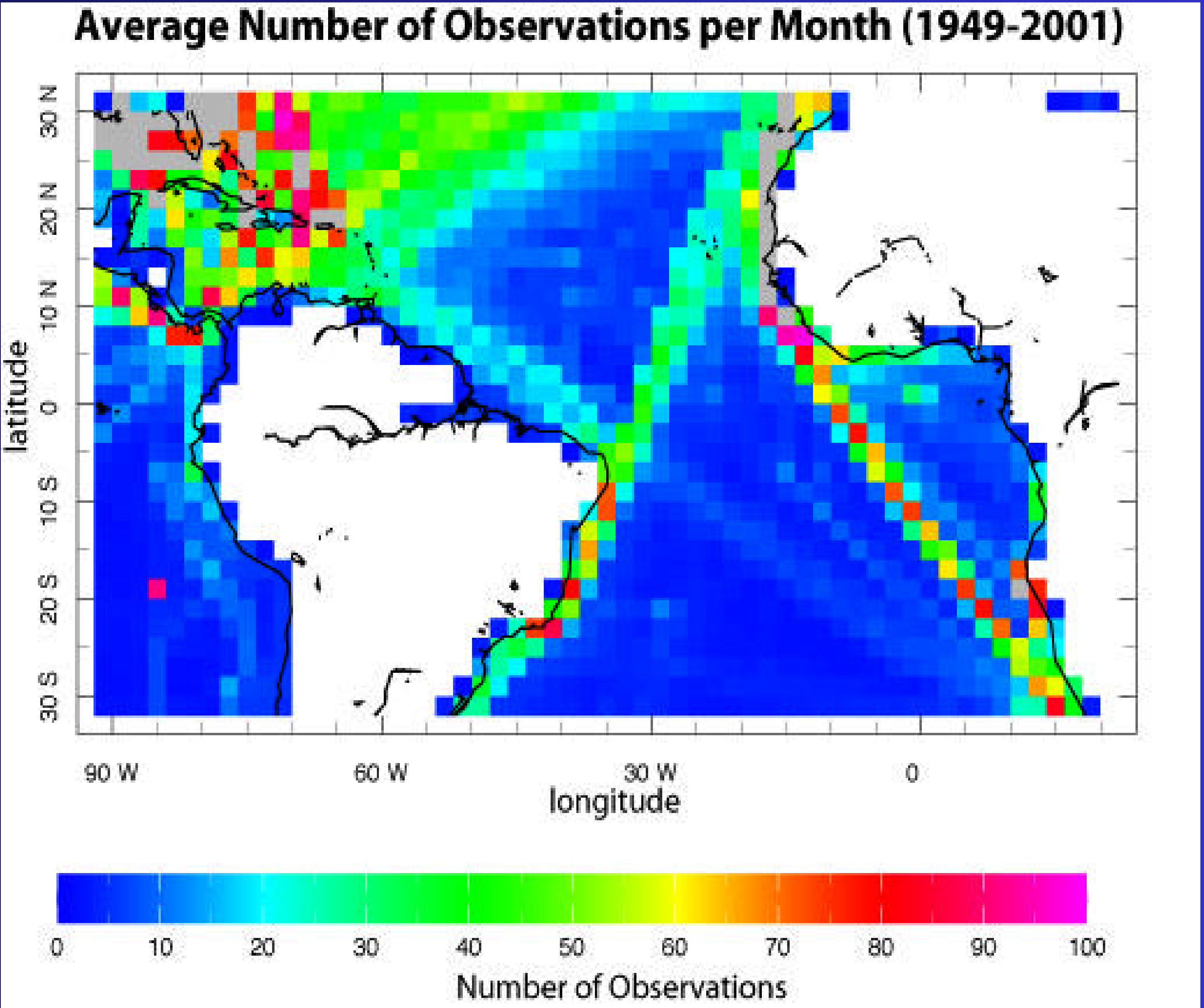
WKG1: *Links between the upper South Atlantic, the deeper ocean and the other basins.* Chair: A. Piola

WKG2: *The South Atlantic links and impacts to regional and global climate.* Chair: A. Grimm

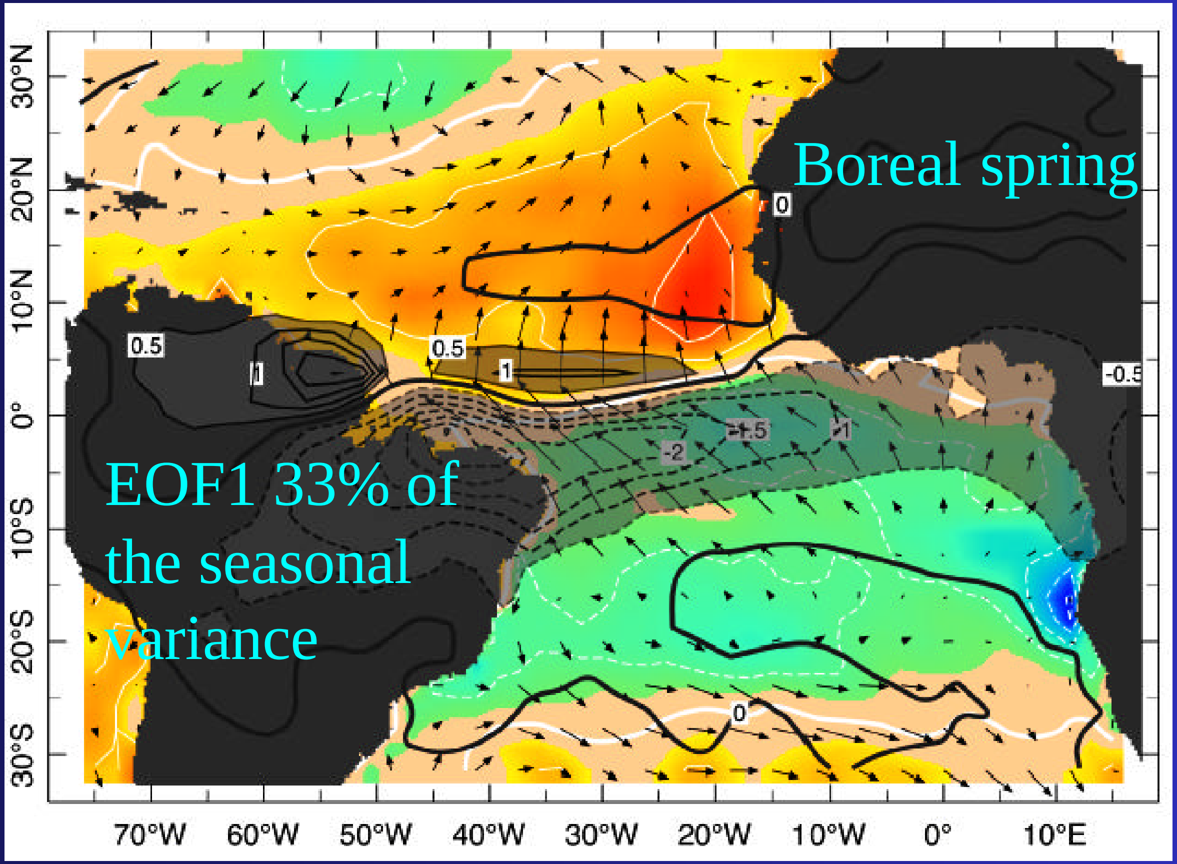
WKG3: *Modeling the Coupled Ocean/Atmosphere System.* Chair: R. Matano

WKG4: *South Atlantic Observing System and Operational Forecast System.* Chair: S. Garzoli

The climate, mean and variability of the SA are less well understood than their Northern Hemisphere counterparts.



The ITCZ variability is highly sensitive to changes in the SST gradients within the broader TA region, particularly in the meridional direction and during the boreal spring.



- •Stronger northward SST gradient
- •Northward cross eq. surface winds
- •Weaker rainfall over SITCZ

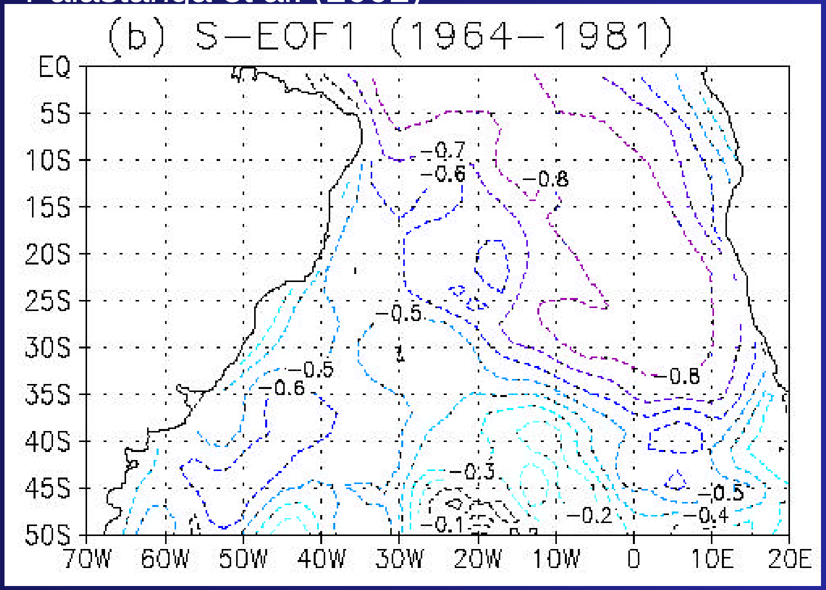
Implies a weakening in the ITCZ strength and a northward shift in its position

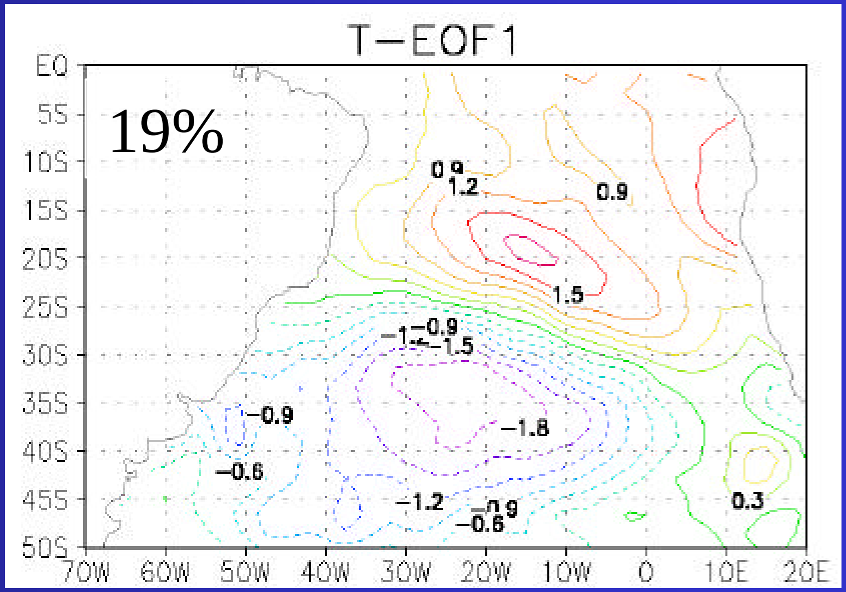
Dominant pattern of surface atmosphere variability in the TA. Black contours depict the 1st EOF of the regional rainfall anomaly. Colored field is the SST anomaly regressed on the principal component time series of the rainfall EOF. Arrows depict the seasonal surface wind vector anomaly, regressed on the same time series. (Kushnir et al., 2003)

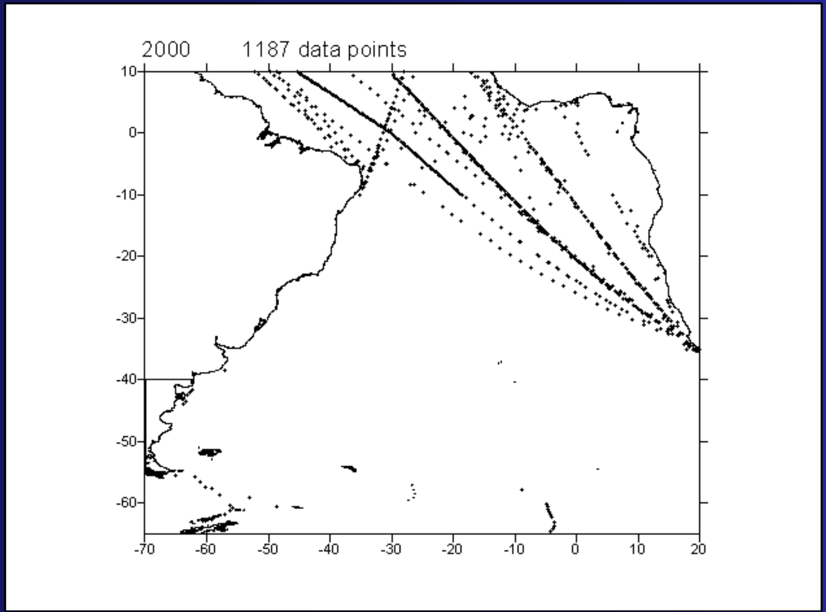
South Atlantic SST variability

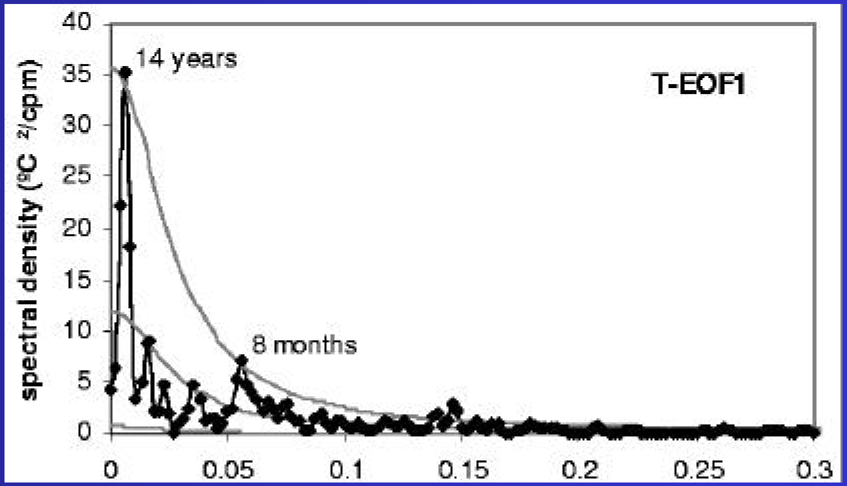
The SST sampling problem

Palastanga et al. (2002)





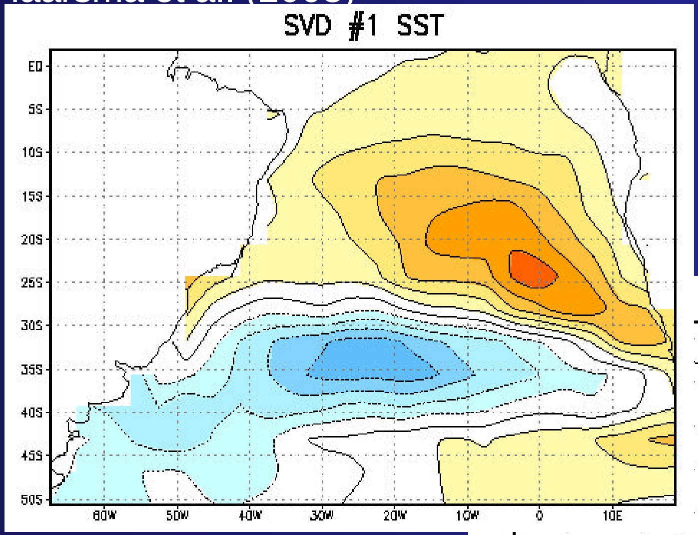




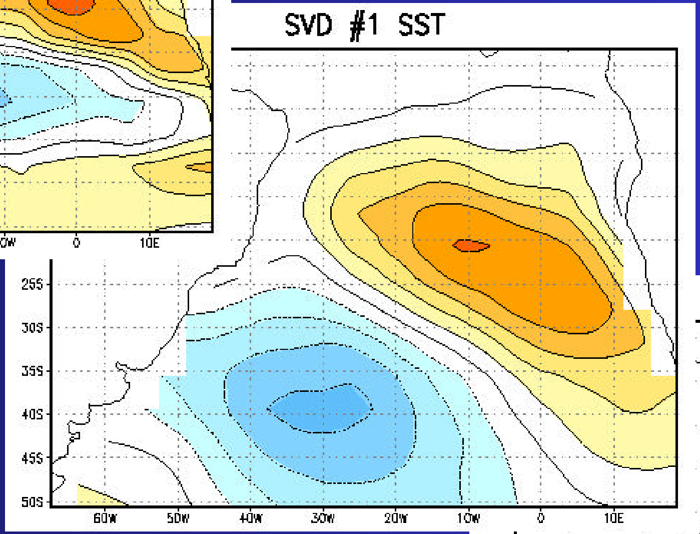
What drives South Atlantic SST variability?

Haarsma et al. (2003)

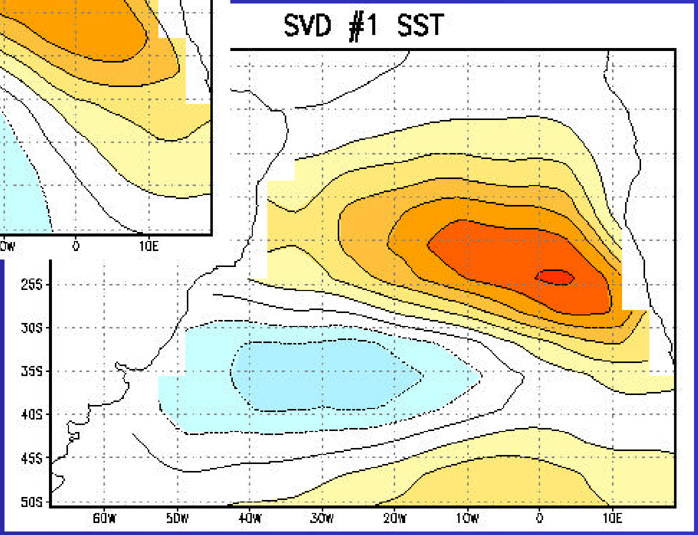
Results from Speedy-MICOM model



SST prescribed

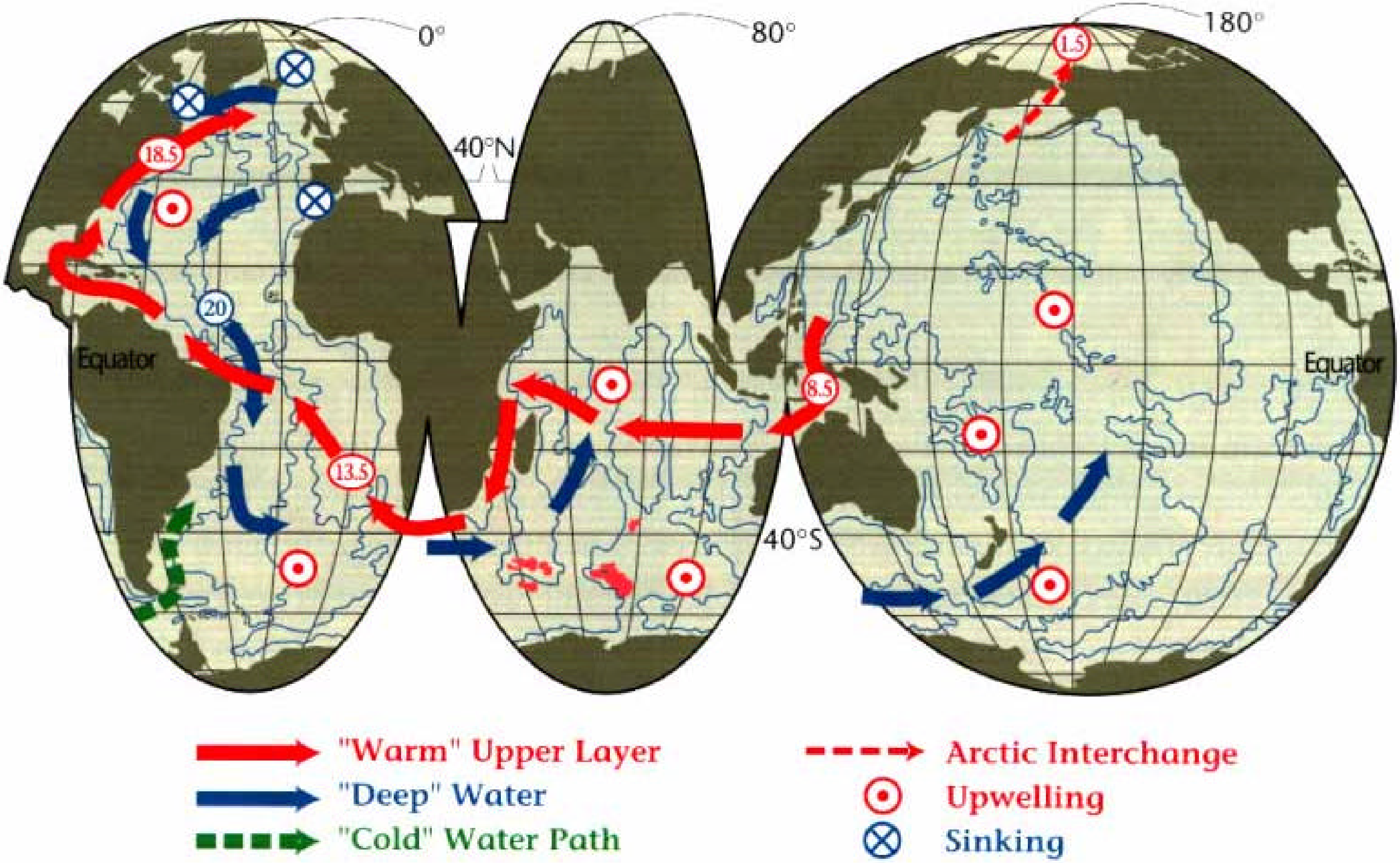


Coupled: heat flux forcing only

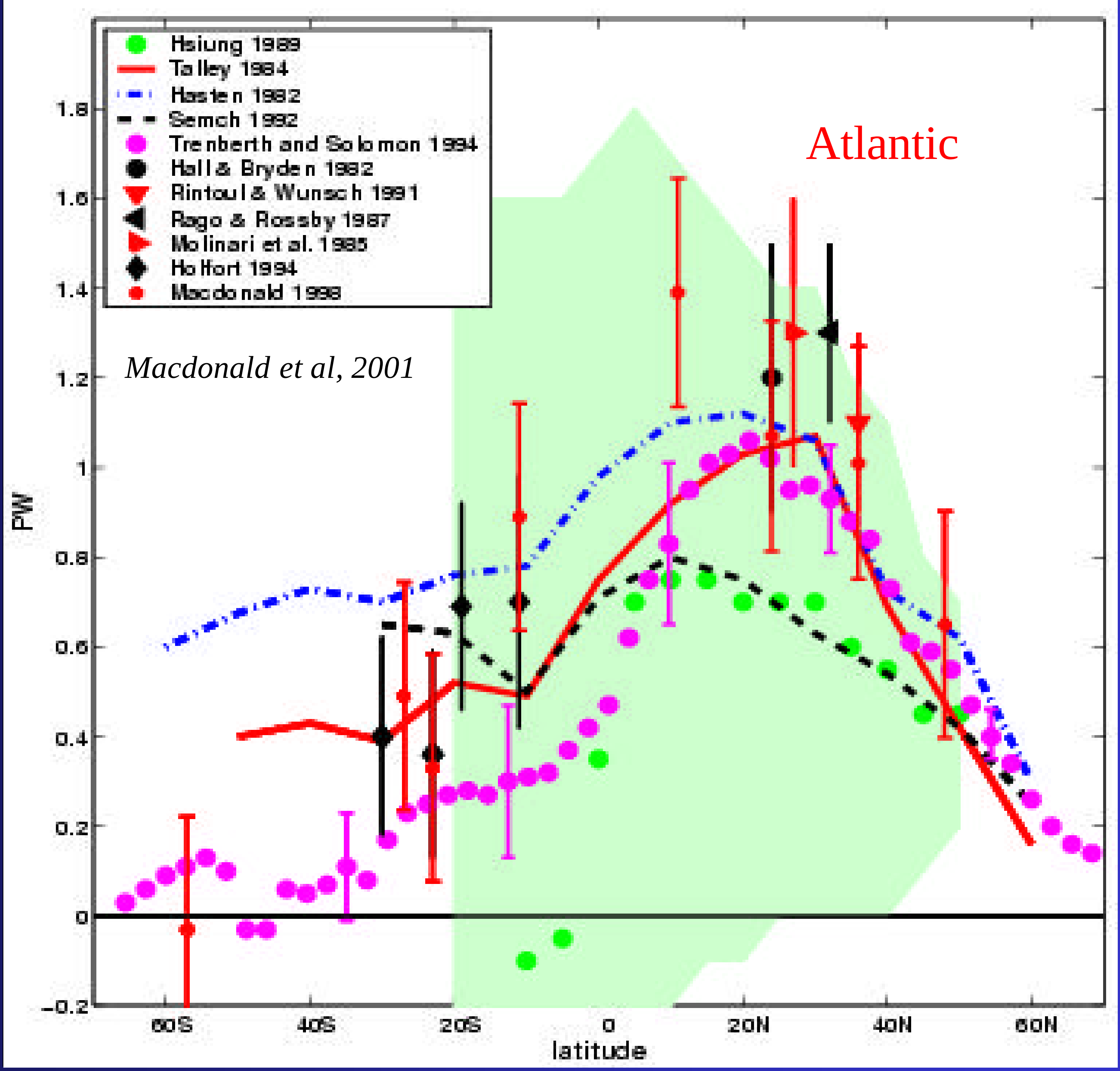


Coupled: Heat flux, Ekman, Wind mixing forcing

Meridional Overturning Circulation (MOC)



Meridional heat flux in the ocean is a key element of the climate system. In the South Atlantic the meridional heat flux is uncertain, estimates vary between -0.4 and +0.9 PW.

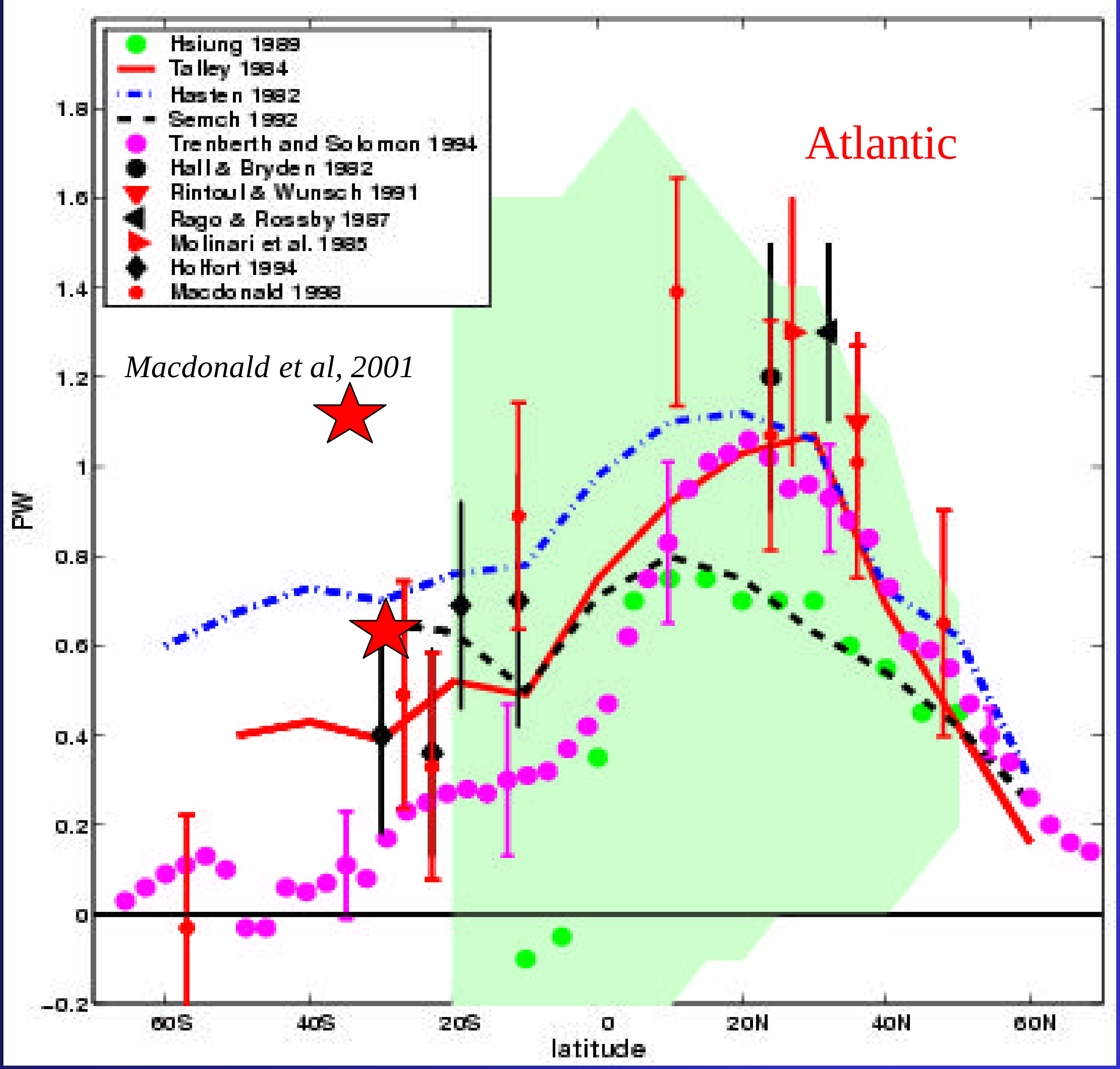


Hsiung 1989
Talley 1984
Hasten 1982
Semch 1992
Trenberth and Solomon 1994
Hall & Bryden 1982
Rintoul & Wunsch 1991
Rago & Rossby 1987
Molinari et al. 1985
Holfort 1994
Macdonald 1998
Atlantic
Macdonald et al, 2001
PW
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
−0.2
60S
40S
20S
0
20N
40N
60N
latitude

Estimates of South Atlantic meridional heat flux near 30°S

Lat °S	Heat Flux PW	Method /	Source
32	0.66-0.88	Inverse	*Fu (1981)*
30	0.69	Sea-air fluxes	*Hastenrath (1982)*
32	0.16-0.68	Direct	*Bennett (1978)*
32.5	0.63	Numerical model	*Donners*
32	0.4	Direct	*Bryan (1962)*
30	0.39	Sea-air fluxes	*Bunker (1980)*
30	0.38	Sea-air fluxes	*Hsiung (1985)*
30	0.3	Inverse	*Macdonald & Wunsch (1996)*
			Ganachaud & Wunsch (2000)
30	0.29	Numerical model	*Marchesiello et al. (1998)*
30	0.26	Numerical model	*Matano (pers. comm., 2003)*
32	0.24	Inverse	*Rintoul (1991)*
30	0.22	Direct	*McDonogh and King (2003)*
30	0.19	Numerical model	*Matano & Philander (1993)*
30	- 0.23	Inverse	*de las Heras & Schlitzer (1999)*

(Piola 2003, personal communication)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0
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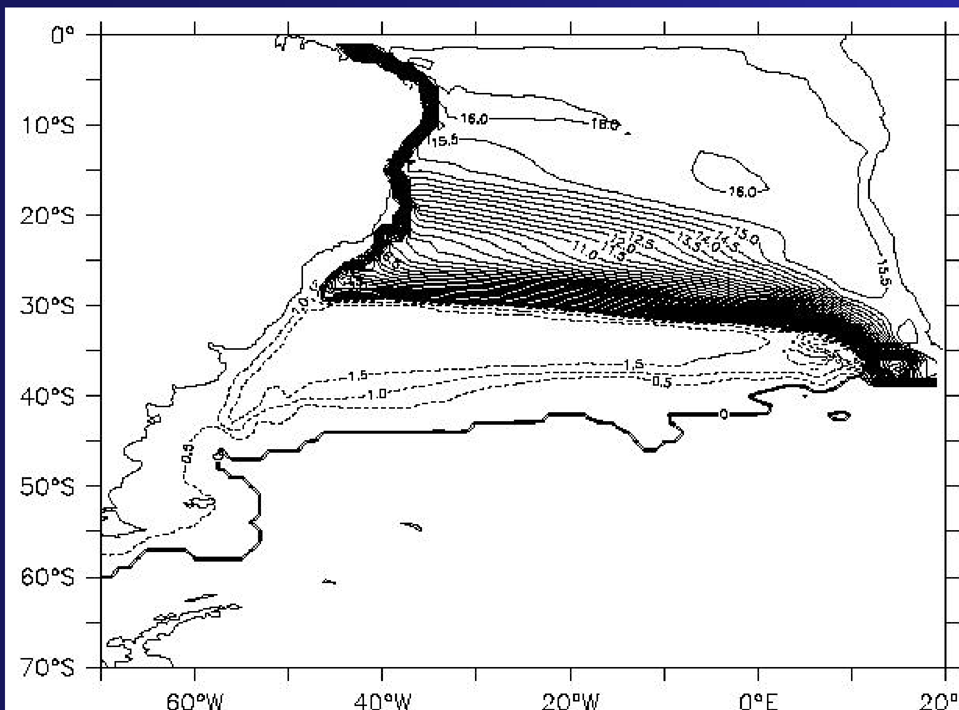
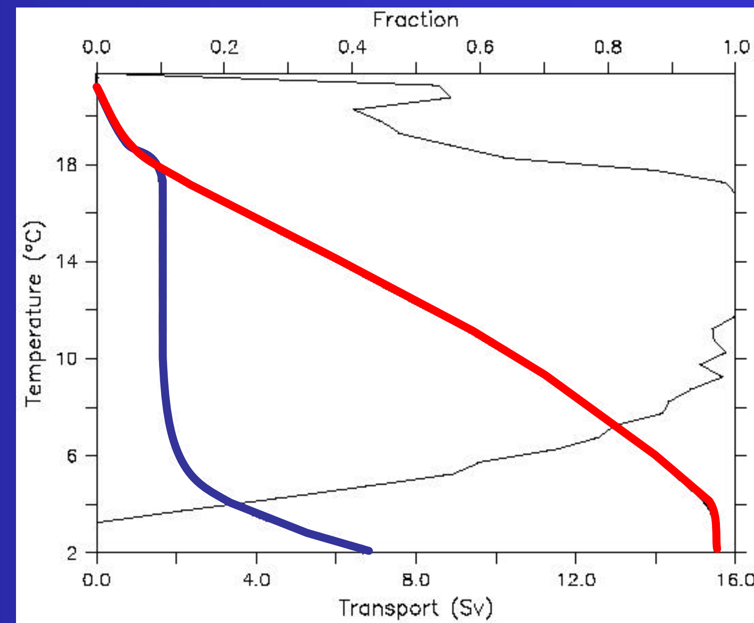
PW
60S
40S
20S
0
20N
40N
60N
latitude

Recent results from OCCAM

(Donners and Drijfhout 2003)



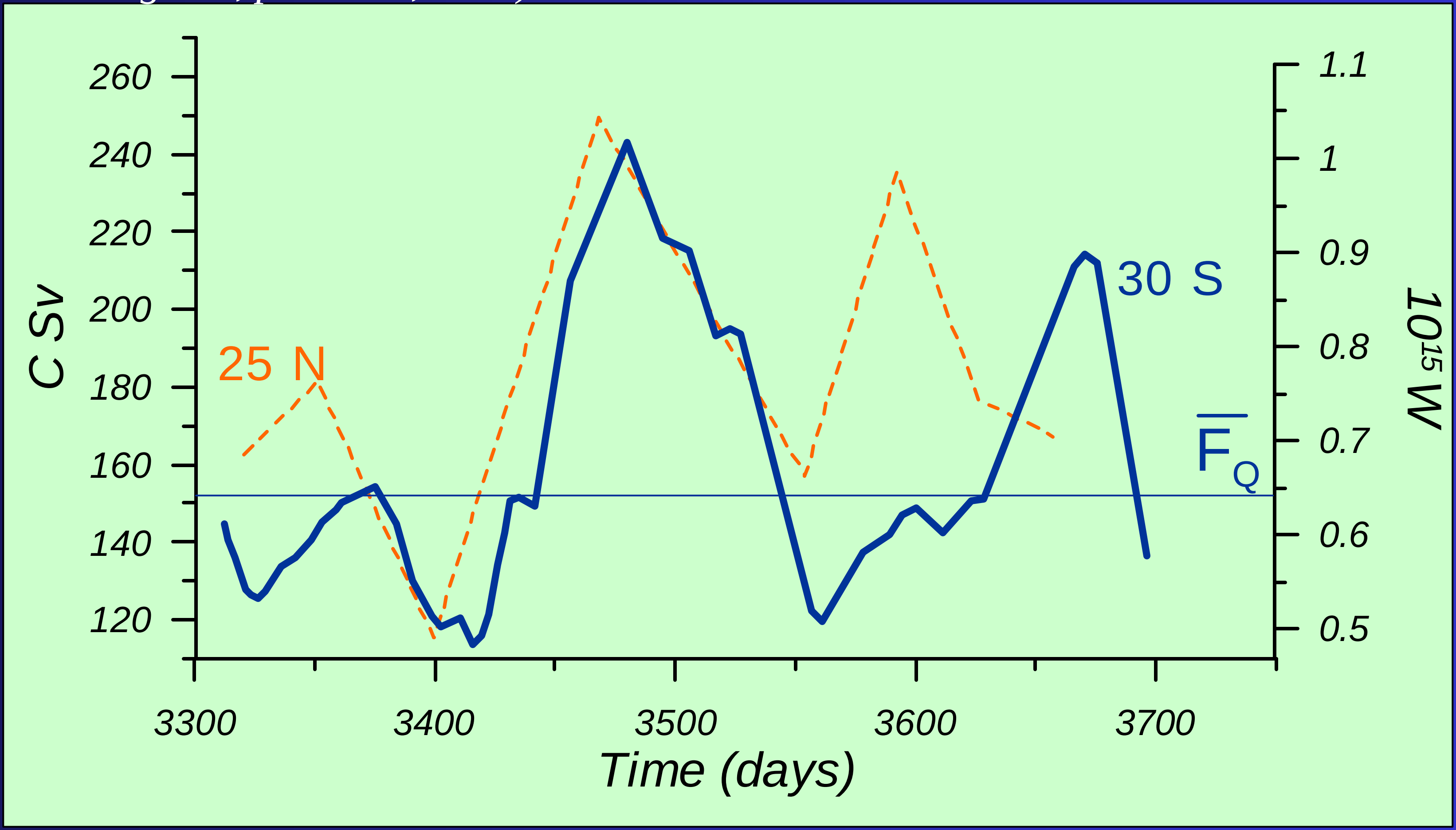
Streamfunction (Sv) of particles traced backward from the Atlantic equator to 20°E or Drake Passage. Only particles lighter than $\sigma_1 = 32.16$ kg/m^3 are included.



The leakage (in Sv) accumulated with temperature at 20°E that reaches the Atlantic equator (red) or recirculates beyond 20°W and reenters the Indian Ocean (blue). The thin line is the fraction of the leakage that is transported to the Atlantic equator.

S. Atlantic heat flux at 30°S from OCCAM

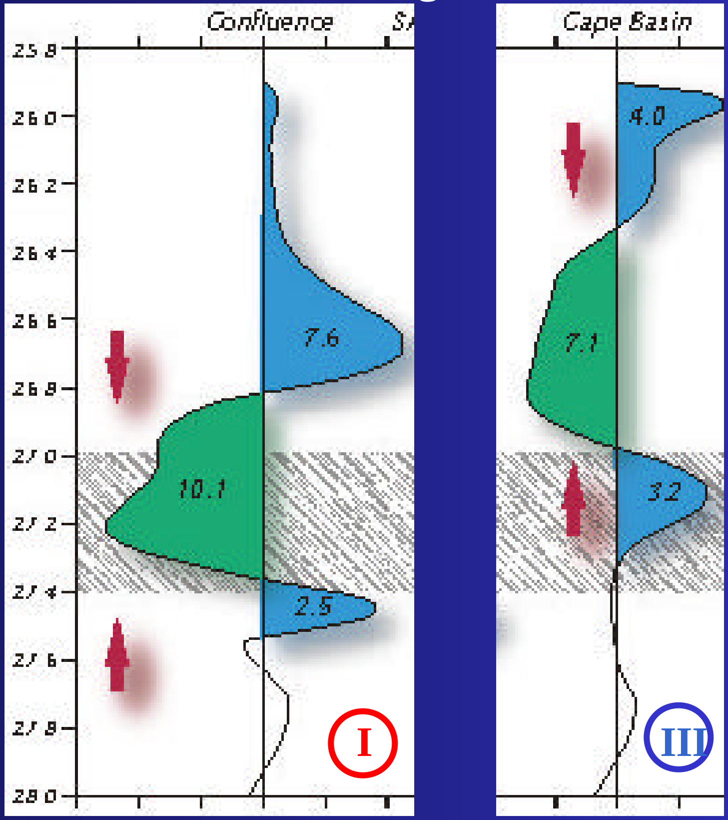
(preliminary results, Donners, p. communication, 2003, and Cunningham, p. comm., 2003)

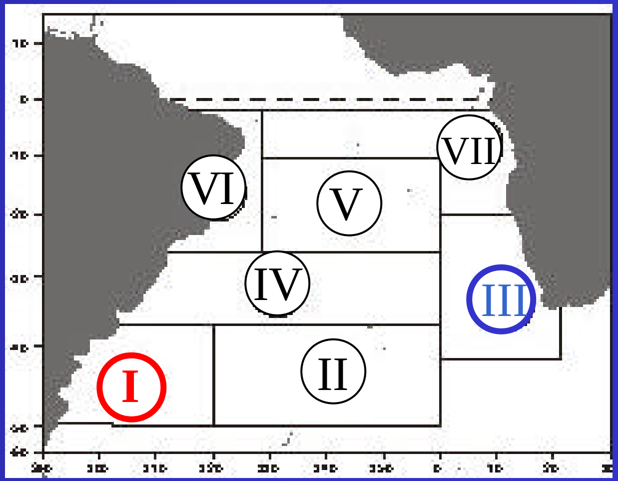


To better understand the global ocean thermohaline circulation and its impact on climate it is necessary to reduce the heat flux uncertainty in the South Atlantic

The relevance of the SA to the MOC depends on whether these circulation passages are affected by their passage through the basin.

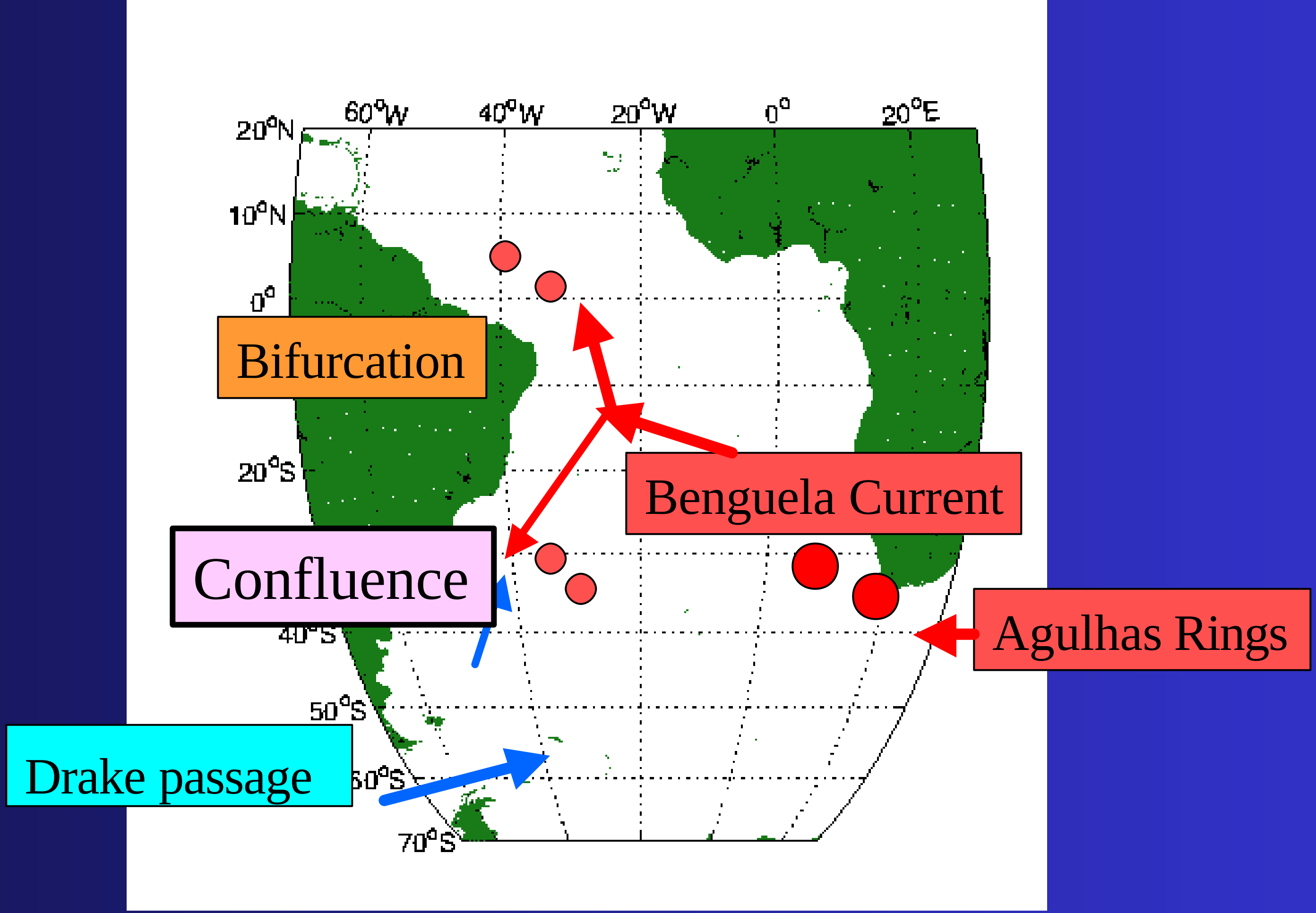
Horizontal divergence



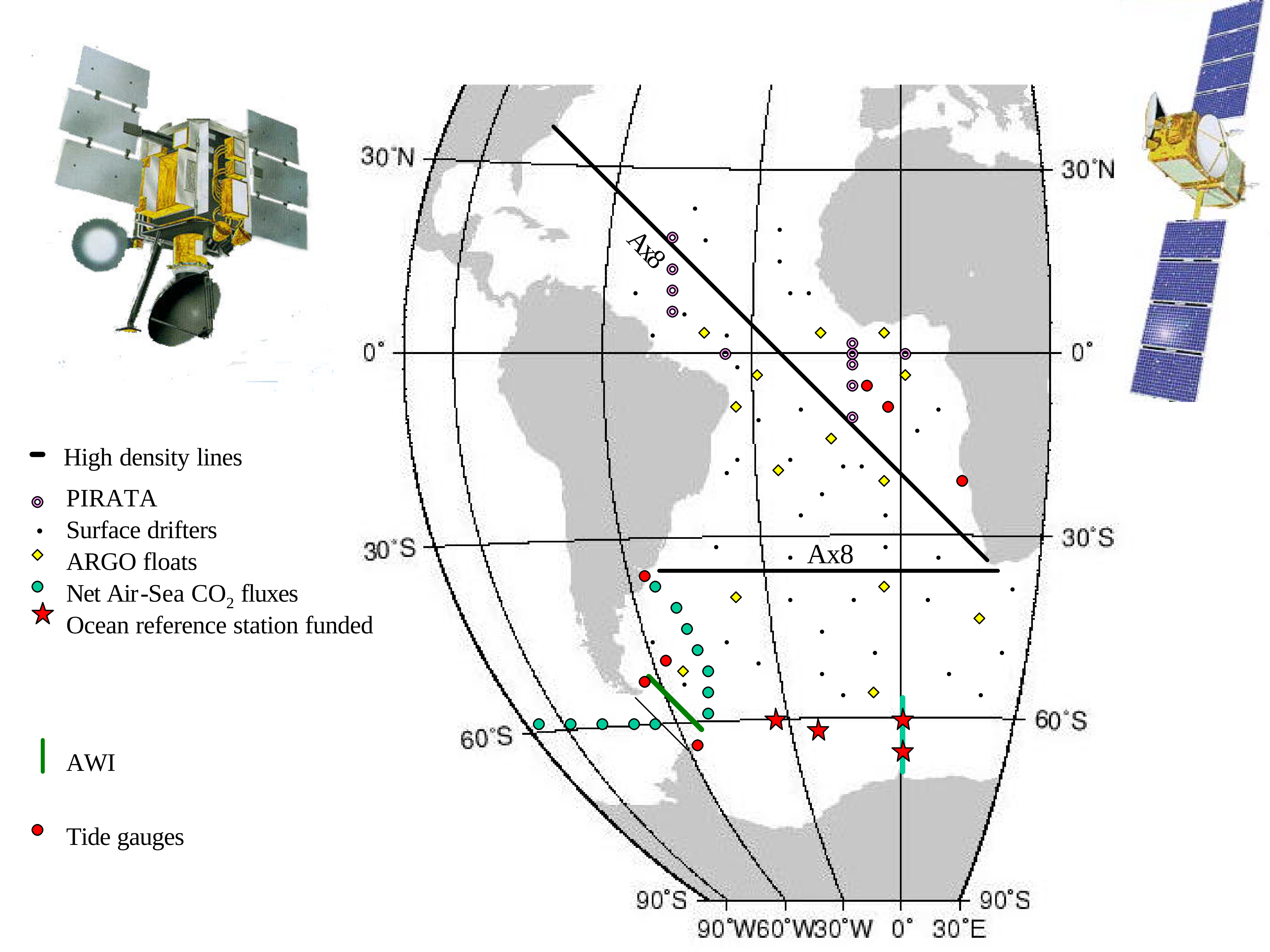


South Atlantic POCM water mass conversions
(Matano et al.)

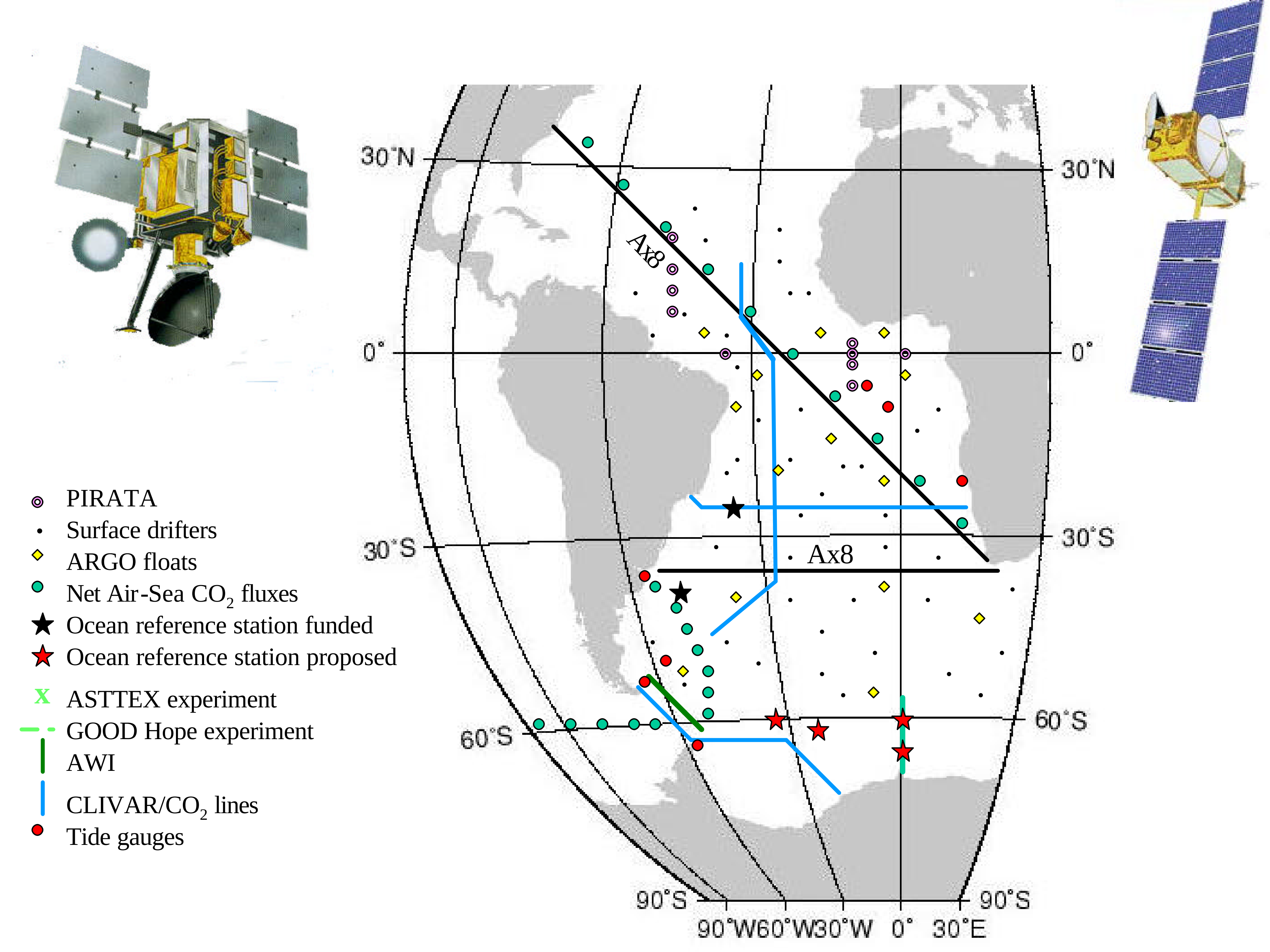
- there are significant water mass conversions within the SA
- these conversions are mostly concentrated in regions of intense mesoscale variability such as the southwestern Atlantic or the Cape Basin.



- **Inflow from the IO (upper layer of the MOC, Benguela Current, Agulhas Rings)**
- **Interhemispheric exchanges (Bifurcation, Boundary Currents)**
- **Interocean exchanges (Drake passage, IO whole water column)**



High density lines
PIRATA
Surface drifters
ARGO floats
Net Air-Sea CO_2 fluxes
Ocean reference station funded
AWI
Tide gauges
30°N
0°
30°S
60°S
90°S
90°W 60°W 30°W 0° 30°E
Ax8
Ax8


30°N
30°N
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60°S
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90°S
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90°W60°W30°W 0° 30°E
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ASTTEX experiment
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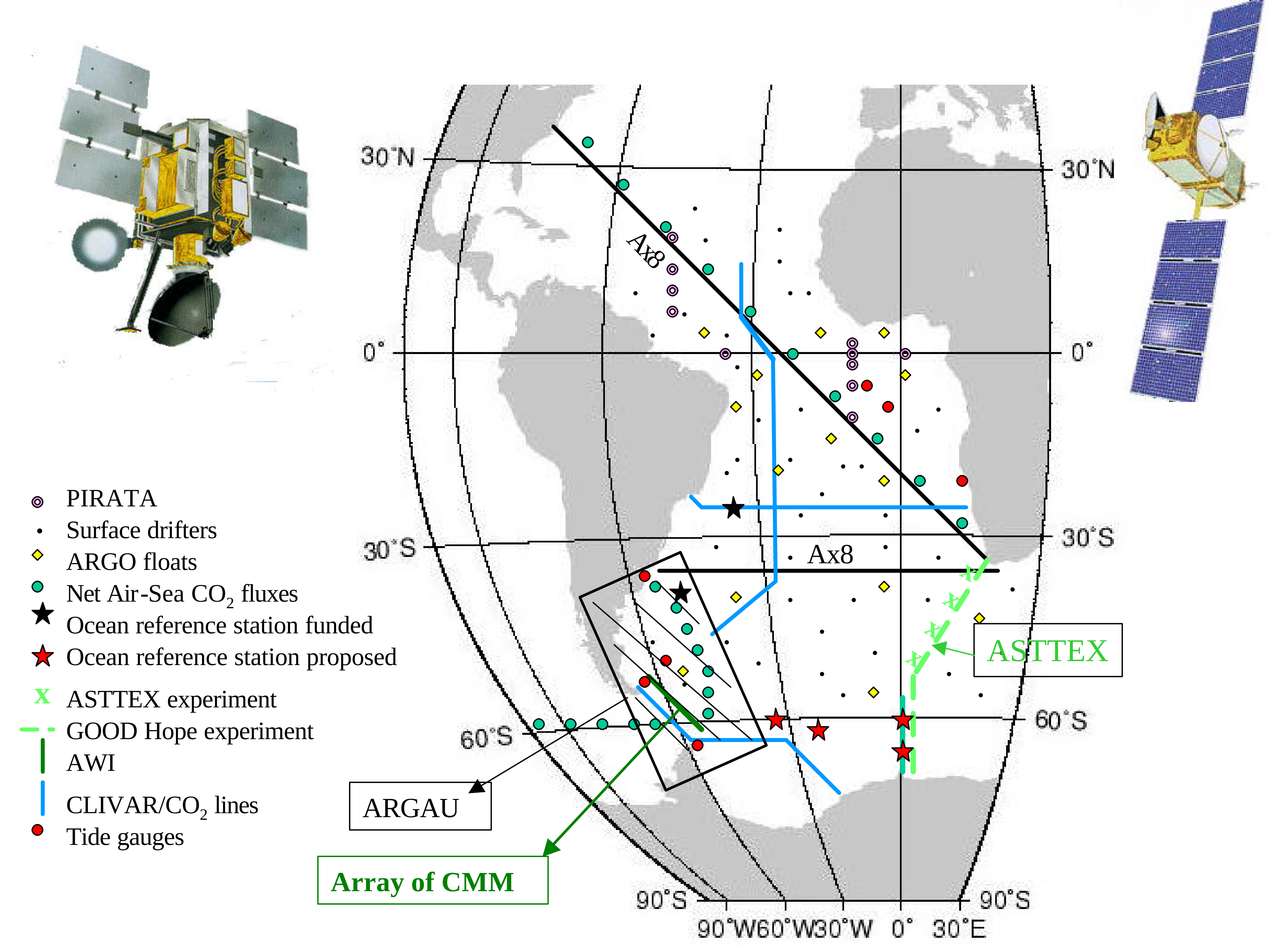

30°N
0°
30°S
60°S
90°S
30°N
0°
30°S
60°S
90°S
90°W
60°W
30°W
0°
30°E
Ax8
Ax8
ASTTEX
ARGAU
Array of CMM
PIRATA
Surface drifters
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GOOD Hope experiment
AWI
CLIVAR/CO_2 lines
Tide gauges

Summary of science issues

1) The South Atlantic contributions to the meridional overturning circulation

- influences the variability of the upper layer interbasin exchange and the meridional heat and freshwater fluxes

- contributes to intense water mass transformations and shortcircuits in the MOC

- influences the variability of the MOC

2) Sea-air interaction, variabiliy from seasonal to decadal time scales

- The ITCZ is highly sensitive to changes in meridional and zonal SST gradients. The SA plays a role in shaping these gradients through ocean atmosphere interactions and subsurface, oceanic pathways (via STCs).

- SST variability in the southeastern (southwestern) South Atlantic has direct impact on precipitation over Africa (South America).

- Several coupled sea-air modes of variability are apparent and required further investigations

3) Impacts on the regional and global climate

SST anomalies in the South Atlantic influences South American and African climate on several timescales, and have predictable components. These SST anomalies may arise primarily from coupled air-sea interactions or forced by the atmosphere.

Southwestern subtropical Atlantic: Diagnostic studies point to a significant role of land-surface processes and possibly ocean-atmosphere interactions in the subseasonal variation of the SACZ interannual variability.

Brazil-Malvinas confluence region: SST anomalies over this region seem to have an impact on cyclogenesis, rainfall and temperature variability over southeastern South America and southwestern Africa.

Gulf of Guinea: SST in this region is a major source of moisture for the West African monsoon.

Tropical South Atlantic: Rainfall over northeast Brazil is better correlated with TSA anomalies (roughly between 20W-5E, 20S-5S) than with TNA anomalies in the preceding seasons.

Southeastern Atlantic: Warm and cold events, originating as equatorial Kelvin waves forced by trade wind anomalies in the western Atlantic, have a significant impact on regional fisheries and southern Africa rainfall.

Subpolar south Atlantic: Recent studies show a relationship between the activity of the SH annular mode and changes in the ACC. The mechanisms of air-sea interaction in the polar regions need to be better understood.

Summary of required observations

1) The southeast and southwest regions of the S. Atlantic are the gateways for entertainment of upper layer water from neighboring oceans and for their modification through mixing and water mass conversions. Time series transport measurements and regional modeling are necessary in these regions.

2) To better understand the role of the S.Atlantic on the MOC it is necessary to reduce the uncertainty in the meridional heat flux through the subtropical band.

3) The establish the origin of the decadal signal observed in SST in the subtropical gyre of the SA Ocean it is required to monitor the variability of SST and of the subtropical gyre.

4) Though the tropical Atlantic is covered by the PIRATA array, additional observations in the tropical-subtropical region appear to be necessary in order to monitor the area of extratropical upwelling and the bifurcation of the SEC. These regions establish the strongest links between tropical SST variability and the largely undersampled subtropical S. Atlantic.

5) Measurements of the heat storage in the upper water column and the air-sea fluxes of heat, mass and momentum are necessary to improve our understanding of SST variability in the subtropical South Atlantic.

Proposed observations, motivated by

Need to decrease meridional heat flux uncertainty

Need to monitor water mass transformation convection/ subduction/mixing

Upper layer flow and regions of high eddy energy

30°S hydrographic section

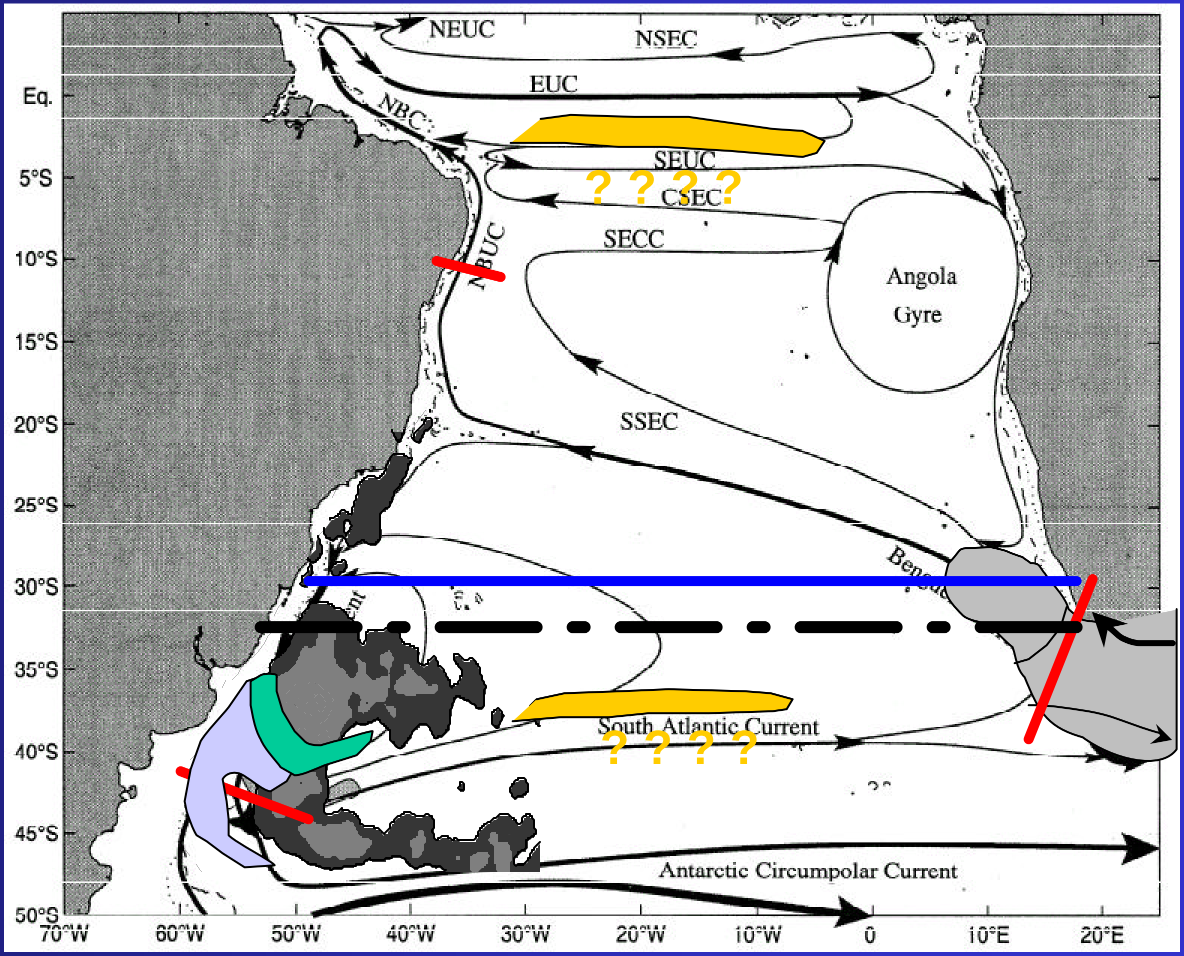
SEC Bifurcation

Subpolar Mode Water

Subtropical Mode Water

STF subduction

Tropical subduction



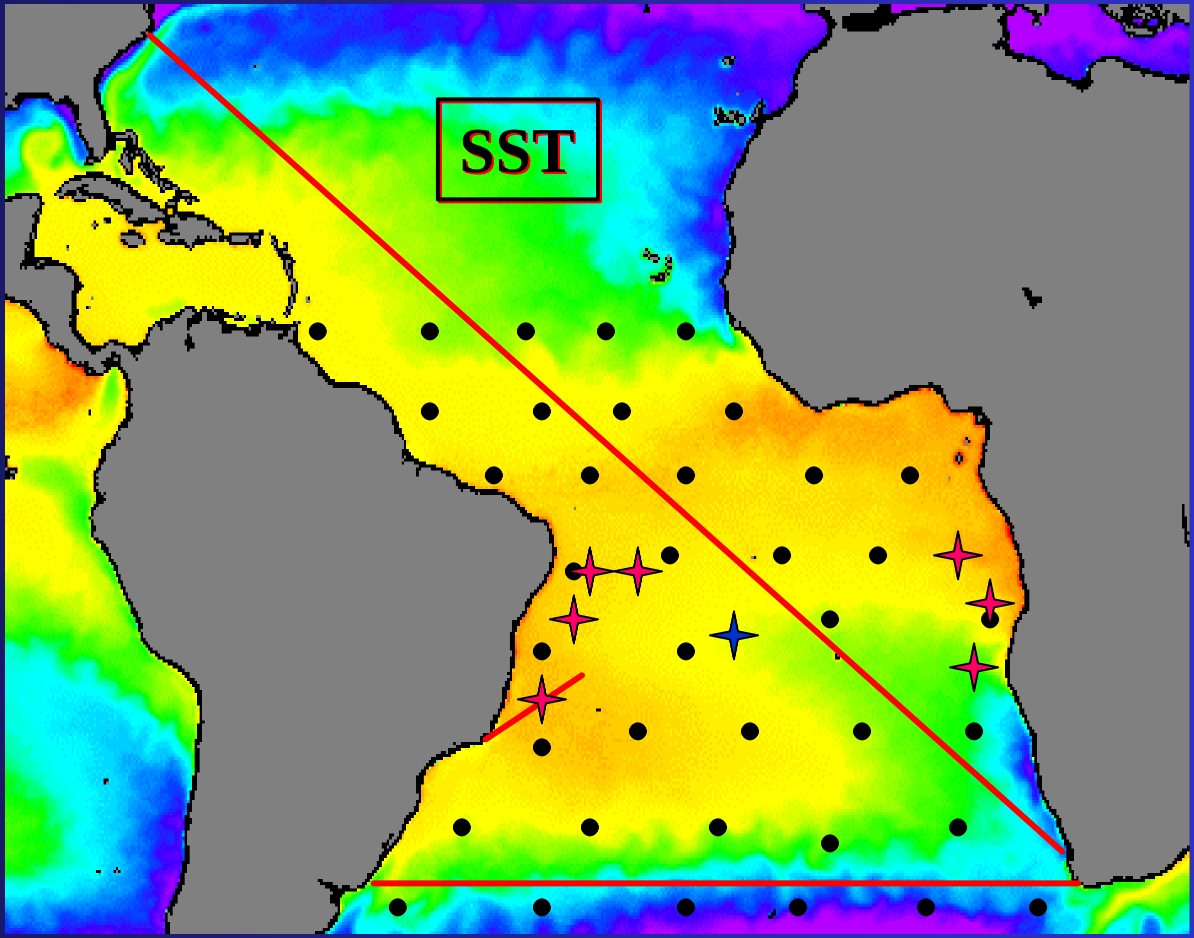
Proposed observations, motivated by

Determine

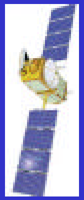
- the leading modes of ocean-atmosphere variability in the South Atlantic.

- the physical mechanisms associated with the climate variability on intraseasonal, interannual and interdecadal timescales (orign of the decadal signal due to variability in the coupled air-sea mode which involves the SST field of the South Atlantic subtropical gyre and the wind stress curl)

- the most important impacts, regionally and globally, of South Atlantic climate modes



- ARGO floats
- PIRATA Extension
- High density lines
- Surface Mooring



Sea Surface height

Sea Surface Temperature

Wind fluxes

There is now sufficient evidence to imply that the SA plays a role in shaping the SST gradients through surface ocean atmosphere interactions and subsurface, oceanic pathways.

To a large extent improved understanding of the S. Atlantic impact on climate is limited by the sparse observations

There are ongoing long term observation efforts in planning for the SA. It is important to coordinate them with the existing ones in the TA.

It is recommended to design and implement a sustained monitoring system for the South Atlantic, which could be maintained in by South Atlantic countries in cooperation with North American and European counterparts.